Mars Pathfinder Project

Rover Camera
Experiment Data Record (EDR)

D-12003

February 1997

Version 1.1

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Draft Printed - March 4, 1997

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ACRONYMS AND ABBREVIATIONS

BTC	Block Truncation Coding
CAHV	Camera model described by four vectors C, A, H and V
CAHVOR	Camera model CAHV with CCD and non-linear distortions accounted
CCD	Charge-Coupled Device
EDR	Experiment Data Record
IMP	Imager for Mars Pathfinder
MIPS	Multimission Image Processing Subsystem
PDS	Planetary Data System
TBD	To Be Determined
URL	Universal Resource Locator
VICAR	Video Image Communication and Retrieval system

ACTION ITEMS FOR CLOSURE

Item	Pages	Assignee	Closure Date
none			

1.0 INTRODUCTION

This specification describes the image data products to be delivered to the Rover Team of the Mars Pathfinder Project by the Multimission Image Processing Subsystem (MIPS). The specifications of the software that produce the products described herein are beyond the scope of this document. Applicable documents used in producing this specification include:

1) Planetary Data System Standards Reference, JPL D-7669, Part 2, version 3.0, November 1992,
2) Planetary Science Data Dictionary Document, JPL D-7116, Revision C, November 1992,
3) Mars Pathfinder Rover Telemetry Dictionary, J. Morrison, A. Mishkin, Mars Rover DFM 94-033,
4) VICAR File Format, JPL, R. Deen, Interoffice Memorandum 384-92-196, September 1992,
5) Mars Pathfinder AIM Phasing and Coordinate Frame Document, JPL D-12103, PF-300-4.0-02.

1.1 Product and Transferal Mechanism

The image data files and labels generated by MIPS software for Mars Pathfinder will be transferred electronically to the Rover Team with automatic electronic notification. Each image file will be generated in VICAR header and file format. A separate, detached Planetary Data System (PDS) label file will be associated with each image file, but not delivered to the Rover Team. The image data files may be generated on any one of the following platforms: Sun Sparcstations with Solaris, Sun Sparcstations with SunOS, Silicon Graphics with IRIX.

1.2 Image Data Processing

The data packaged in the files will be decoded, decompressed Rover image data in single frame and band-sequential color form as an Experiment Data Record (EDR) . The Rover's front cameras generate monochrome (greyscale), stereo image pairs. The Rover's rear camera is a color camera and generates a single band, single frame image that can be decoded into a band-sequential color image. Thus for one imaging event with the rear camera, two image files can be produced, a packed-color image of one band or an unpacked, band-sequential image consisting of red, green, and blue bands.

The single frame form is an image of maximum dimensions 492 lines by 768 samples. Because the Rover camera CCD has a photosensitive area of 484 rows by 768 samples, a majority of full-frame images will be 484 lines by 768 samples. The color, band-sequential form is an ordered set of red, green, and blue image bands, each band with a maximum dimension of 768 lines by 492 samples. The VICAR software used to generate these image products is described in Table 1.

Table 1. — *VICAR Software for Mars Pathfinder Rover Image Data Files*

Application	Description
MPFTELEMPROC	Fetches the image Standard Formatted Data Unit (SFDU) records from the Telemetry Delivery Subsystem (TDS), and reconstructs the image file from the telemetry data. This application produces a VICAR image file with a subset of descriptive label items. It also accesses the catalog (or SPICE kernels) to supplement the ancillary image information from the telemetry data. Note that the rear camera images are rotated 90 degrees within MPFTELEMPROC such that output image data has its vertical dimension along the image's line dimension, just as the front cameras do.
MPFRVRCLR	Generates color image from the Rover's rear camera.
MPFCAHV	Converts uncorrected images to a corrected CAHV camera model.

2.0 DETAILED SPECIFICATION

The following section describes in greater detail the files to be received by the Rover Team.

2.1 Structure and Organization Overview

For each Rover image, two files are created: 1) image file, and 2) a detached PDS label. These files together constitute a set of data to be managed and archived within MIPS as one unit. The naming convention of these files must be retained as they are copied or moved in order to properly maintain the image and ancillary data (see section 2.2).

2.1.1 Image File

Images will be available to the Rover team in VICAR file format. A VICAR image file consists of two major parts: the image header or VICAR label, which describes what the file is, and the image area, which contains the actual image data. Figure A describes this structure graphically. The following text is a direct excerpt from the VICAR File Format memorandum [5], which is available on MIPS' homepage at URL http://www.mipl.jpl.nasa.gov/vic_file_-fmt.html. This further explains the VICAR file structure.

> The labels (VICAR) are potentially split into two parts, one at the beginning of the file, and one at the end. Normally, only the labels at the front of the file will be present. However, of the EOL keyword in the system label (described below) is equal to 1, then the EOL labels (End Of file Labels) are present. This happens if the labels expand beyond the space allocated for them. The VICAR file is treated as a series of fixed-length records, of size RECSIZE (see below). The image area always starts at a record boundary, so there may be unused space at the end of the label, before the actual image data starts.
>
> The label consists of a sequence of "keyword=value" pairs that describe the image (or data file), and is made up entirely of ASCII characters. Each keyword-value pair is separated by spaces. Keywords are strings, up to 32 characters in length, and consist of uppercase characters, underscores (_), and numbers (but should start with a letter). Values may be integer, real, or strings, and may be multiple (e.g. an array of 5 integers, but types cannot be mixed in a single value). Spaces may appear on either side of the equals character (=), but are not normally present.
>
> The first keyword is always LBLSIZE, which specifies the size of the label area in bytes. LBLSIZE is always a multiple of RECSIZE, even if the labels don't fill up the record. If the labels end before LBLSIZE is reached (the normal case), then a 0 byte terminates the label string. If the labels are exactly LBLSIZE bytes long, a null terminator is *not necessarily* present. The size of the label string is determined by the occurrence of the first 0 byte, or LBLSIZE bytes, whichever is smaller.
>
> If the system keyword EOL has the value 1, then End-Of-file Labels exist at the end of the image area (see above). The EOL labels, if present, start with another LBLSIZE keyword, which is treated exactly the same as the main LBLSIZE keyword. The length of the EOL labels is the smaller of the length to the first 0 byte or the EOL's LBLSIZE. Note that the main LBLSIZE does *not* include the size of the EOL labels. In order to read in the full label string, simply read in the EOL labels, strip off the LBLSIZE keyword, and append the rest to the end of the main label string.

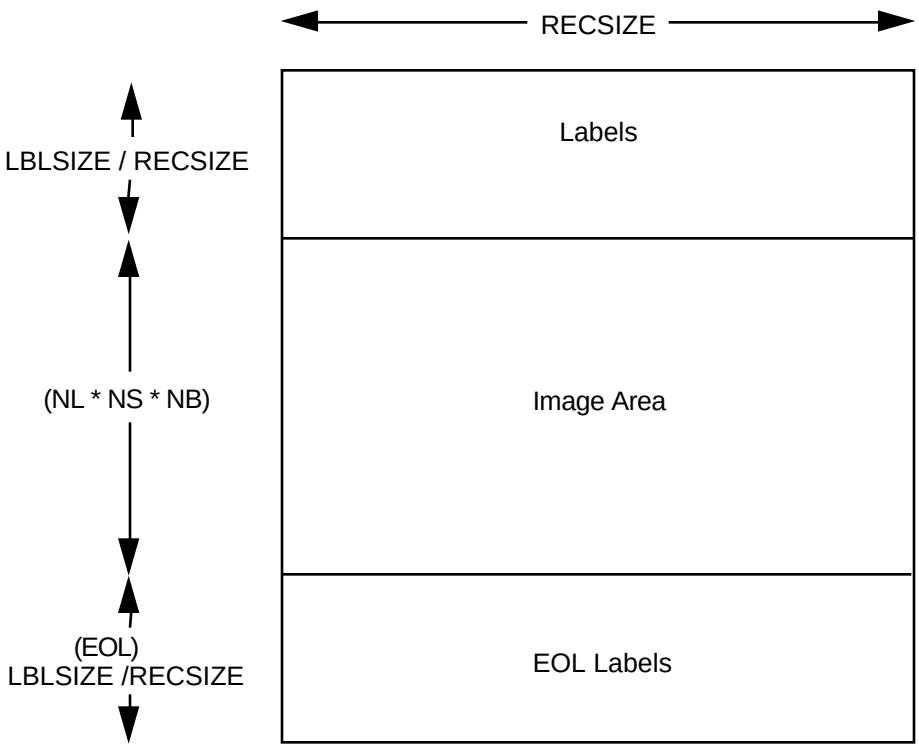

Figure A. — *VICAR File Structure for a Rover Image File*

In Figure A, NL is the number of image lines; NS is the number of image samples per line; and NB is the number of image bands. LBLSIZE is the total number of bytes within the VICAR label, and RECSIZE is the total number of bytes per file record.

The nominal Rover image frame size is 484 lines by 768 samples for monchrome images and 768 lines by 484 samples for band-sequential color images, but may be smaller based on commanded image size. The image data format is unsigned character (8-bit pixels).

The VICAR header or label is a part of this image file. This label is organized in an ASCII, keyword-equals-value format and contains information regarding the observation which produced the spectrum data. This observation information includes general descriptors such as target and time tags of the start of image acquisition, camera and spacecraft state parameters, data compression information, viewing and lighting geometry, spacecraft position and camera pointing, image dimensions, and processing history. See Figure B for the label keywords to be included in the VICAR label. The figure shows a template that describes the displayed format of this VICAR label. All keywords are described in detail in the Appendix. Note that delivered images may have keywords listed in a slightly different order than what is shown here.

Figure B. — *VICAR Label Listing for Mars Pathfinder Rover EDR*

```
********** File r<image_id>.img **********
   3 dimensional IMAGE file
   File organization is BSQ
   Pixels are in BYTE format from a <host type> host
   1 bands
   484 lines per band
   768 samples per line
```

0 lines of binary header
0 bytes of binary prefix per line

---- Property: RVR_COMMANDS ----
APPLICATION_PACKET_ID = nn
APID_DESCRIPTION = '*string describing the purpose of observation*'
COMMAND_SEQUENCE_NUMBER = nnnnn
COMMAND_SEQUENCE_PARTITION = nn

---- Property: OBSERVATION ----
MISSION_NAME = 'MARS PATHFINDER'
SPACECRAFT_NAME = 'PATHFINDER ROVER' or 'SIM ROVER'
INSTRUMENT_NAME = <'Rover Left Camera', 'Rover Right Camera' or
'Rover Rear Camera'>
TARGET_NAME = '*target name*'
MESSAGE_PACKET_NUMBER = nnnnn
IMAGE_ID = '<APID code letter><command_sequence_partition>
<command_sequence_number>'
FRAME_ID = <'LEFT' or 'RIGHT' or 'REAR'>
IMAGE_TIME='yyyy-mm-ddThh:mm:ss.mmm'
SPACECRAFT_CLOCK_START_COUNT= nnnnnnn
LOCAL_TIME = hh:mm:ss.fff
EXPOSURE_DURATION = nnnnn
INSTRUMENT_TEMPERATURE = ffff.fff
SOLAR_AZIMUTH = fff.fff
SOLAR_ELEVATION = ±ff.fff
SPACECRAFT_LATITUDE = ±ff.fff
SPACECRAFT_LONGITUDE = fff.fff

Figure B. — *VICAR Label Listing for Mars Pathfinder Rover EDR (continued)*

ROVER_POSITION = (x.xxxxexx,x.xxxxexx)
ROVER_HEADING = x.xxex
LINEAR_ACCELEROMETER_READINGS = (x.xxxxexx,x.xxxxexx)
FIRST_LINE = nnnn
FIRST_LINE_SAMPLE = nnnn

---- Property: CAMERA_MODEL ----
FOCAL_CENTER_VECTOR = <array of 3 floating point numbers>
POINTING_DIRECTION_VECTOR = <array of 3 floating point numbers>
HORIZONTAL_IMAGE_PLANE_VECTOR = <array of 3 floating point numbers>
VERTICAL_IMAGE_PLANE_VECTOR = <array of 3 floating point numbers>
CAMERA_MODEL_TO_MFX_TRANSFORM = <array of 12 floating point numbers>
SURFACE_FIXED_CAMERA_AZIMUTH = fff.fff
SURFACE_FIXED_CAMERA_ELEVATION = ±ff.fff
AZIMUTHAL_FIELD_OF_VIEW = fff.fff
ELEVATIONAL_FIELD_OF_VIEW = fff.fff
PIXEL_HEIGHT = fff.fff
PIXEL_WIDTH = fff.fff

---- Property: BTC_DECOMPRESSED ----
INSTRUMENT_COMPRESSION_TYPE = 'Block Truncation Coding (BTC)'
INSTRUMENT_COMPRESSION_TYPE_DESCRIPTION = '*string describing the encoding type*'
INSTRUMENT_COMPRESSION_BLOCKS = nnnnn
INSTRUMENT_COMPRESSION_BLK_SIZE = (4,4)
INSTRUMENT_COMPRESSION_RATE = fff.fff
INSTRUMENT_COMPRESSION_RATIO = fff.fff

--- Task: MPFTELEMPROC -- User: <*username*> -- <*date and time for product creation* >----
RECEIVED_PACKETS = nnnn
EXPECTED_PACKETS = nnnn
PRODUCT_ID = 'RVR_EDR_<image_id>_<frame_id>'
PRODUCT_CREATION_TIME = 'yyyy-mm-ddThh:mm:ss.mmm'
SOFTWARE_VERSION_ID = 'Version of MIPS telemetry processing software used'
SOURCE_PRODUCT_ID = '<SPK file name>, <PCK file name>, <EK file name>, . . .'
TLM_CMD_DISCREPANCY_FLAG = <'TRUE' or 'FALSE'>

2.1.2 PDS Detached Label File

For every image data file, there is a corresponding PDS detached label file. This file adheres to the Planetary Data System standard for ancillary data management. The file contains information regarding the observation which produced the image. This observation information includes general descriptors such as target and time tags of the start of image acquisition, camera and spacecraft state parameters, data compression information, viewing and lighting geometry, spacecraft position and camera pointing, image dimensions, and processing history.

The PDS label file is an object-oriented file; the object to which the label refers is denoted by a statement of the form:

```
^object = location
```

in which the carat character (^, also called a pointer in this context) indicates that the object starts at the given location. In a detached label, the location denotes the name of the file containing the object, along with the starting record or byte number, if there is more than one object. For example:

```
^IMAGE = ("rL039230.img",3)
```

indicates that the IMAGE object begins at record 3 of the file rL039230.img, in the same directory as the detached label file.

All detached labels contain 80-byte fixed-length records, with a carriage return character (ASCII 13) in the 79th byte and a line feed character (ASCII 10) in the 80th byte. This allows the files to be read by the HFS, MacOS, DOS, OS2, Unix, and VMS operating systems. Also, all PDS label files have a file extension of ".lbl".

Figure C is a template of the Rover EDR detached PDS label. See the Appendix for detailed definitions and formatting information for the label items. Also note label item values that are capitalized or enclosed in quotes and not italicized represent label item values to be written verbatim.

Figure C. — *Template of Mars Pathfinder Rover EDR PDS Label File*

```
/* File Format and Length */
PDS_VERSION_ID              = PDS3
RECORD_TYPE                 = FIXED_LENGTH
RECORD_BYTES                = 80
FILE_RECORDS                = number of label records in the file

/* Pointers to Start Records of Objects in File */
^IMAGE                      = ("r<image_id>.<file extension>",<# of VICAR label records>)

/* Image Description */
MISSION_NAME                = "MARS PATHFINDER"
SPACECRAFT_NAME             = "PATHFINDER ROVER"
INSTRUMENT_NAME             = <"Rover Right Camera" or "Rover Left Camera"
                                  or "Rover Rear Camera">
TARGET_NAME                 = planetary body, feature or region
```

Figure C. — *Template of Mars Pathfinder Rover EDR PDS Label File (continued)*

```
IMAGE_ID                        = "<APID code letter><command_sequence_partition>
                                        <command_sequence_number>"
FRAME_ID                        = <LEFT or RIGHT or REAR>

RECEIVED_PACKETS                = nnnn
EXPECTED_PACKETS                = nnnn

DATA_SET_NAME                   = "Mars Pathfinder Mars Rover Level 2 Experiment
                                        Data Record Vx.x"
DATA_SET_ID                     = "MPF-M-RVR-2-EDR-V1.0"
PRODUCT_ID                      = "RVR_EDR_<image_id>_<frame_id>"
PRODUCT_CREATION_TIME           = yyyy-mm-ddThh:mm:ss.fff

PRODUCER_ID                     = "Rover Team / MIPS "
PRODUCER_FULL_NAME              = "Mars Pathfinder Rover Team in concert with
                                        the Multimission Image Processing Subsystem"
PRODUCER_INSTITUTION_NAME       = "Jet Propulsion Laboratory (JPL)"

SOURCE_PRODUCT_ID               = {<SPK file name>, <PCK file name>, <EK file name>, etc.}
SOFTWARE_VERSION_ID             = "Version of MIPS telemetry processing software used"
PROCESSING_HISTORY_TEXT         = "Listing of processing steps to produce this image."
TLM_CMD_DISCREPANCY_FLAG        = "Indicator of mismatches between commands and telem."

/* Time tags and observation descriptors */
APPLICATION_PACKET_ID           = nnn
APID_DESCRIPTION                = "string describing the  purpose of observation"
MESSAGE_PACKET_NUMBER           = nnnnn
COMMAND_SEQUENCE_NUMBER         = nnnnn

IMAGE_TIME                      = yyyy-mm-ddThh:mm:ss.fff
SPACECRAFT_CLOCK_START_COUNT    = nnnnnnn
LOCAL_TIME                      = hh:mm:ss.fff
EXPOSURE_DURATION       = nnnnn

/* Camera diagnostics */
INSTRUMENT_TEMPERATURE          = ±fff.fff

/* Lighting geometry */
SOLAR_AZIMUTH                   = fff.fff
SOLAR_ELEVATION                 = ±ff.fff

/* Rover spacecraft position */
SPACECRAFT_LATITUDE             = ±ff.fff
SPACECRAFT_LONGITUDE            = fff.fff
```

Figure C. — *Template of Mars Pathfinder Rover EDR PDS Label File (continued)*

```
/* Rover spacecraft position and heading */
ROVER_POSITION                                  = (x.xxxxexx, x.xxxxexx)
ROVER_HEADING                                   = x.xxexx
LINEAR_ACCELEROMETER_READINGS                   = (x.xxxxexx, x.xxxxexx)

/* Camera model information */
FOCAL_CENTER_VECTOR                             = <array of 3 floating point numbers>
POINTING_DIRECTION_VECTOR                       = <array of 3 floating point numbers>
HORIZONTAL_IMAGE_PLANE_VECTOR                   = <array of 3 floating point numbers>
VERTICAL_IMAGE_PLANE_VECTOR_                    = <array of 3 floating point numbers>
CAMERA_MODEL_TO_MFX_TRANSFORM                   = <array of 12 floating point numbers>

AZIMUTHAL_FIELD_OF_VIEW   = fff.fff
ELEVATIONAL_FIELD_OF_VIEW         = fff.fff
PIXEL_HEIGHT                = fff.fff
PIXEL_WIDTH                       = fff.fff

/* Compression Statistics, occurs only if compression is performed */
INSTRUMENT_COMPRESSION_TYPE               = <"Block Truncation Coding (BTC)">
INSTRUMENT_COMPRESSION_DESCRIPTION    = "string describing the encoding type"
INSTRUMENT_COMPRESSION_BLOCKS  = nnnnn
INSTRUMENT_COMPRESSION_BLK_SIZE         = (4,4)
INSTRUMENT_COMPRESSION_RATE             = fff.fff
INSTRUMENT_COMPRESSION_RATIO    = fff.fff

/* Image Object */
OBJECT                          = IMAGE
        LINES                   = nnnn
        LINE_SAMPLES            = nnnn
        SAMPLE_TYPE                     = MSB_UNSIGNED_INTEGER
        SAMPLE_BITS             = 8
        SAMPLE_BIT_MASK     = 2#11111111#
        CHECKSUM                =  <32-bit integer value>
        FIRST_LINE              = nnnn
        FIRST_LINE_SAMPLE       = nnnn
        BAND_SEQUENCE       = (RED, GREEN, BLUE)            /* present only for color images */
        BAND_STORAGE_TYPE = "BAND SEQUENTIAL"   /* present only for color images */
        BANDS                   = 3                             /* present only for color images */
END_OBJECT                      = IMAGE
END
```

2.2 File Naming Conventions

The following naming convention standard for Rover image data files is to be maintained by MIPS as a means of files management. It is suggested for all end-users of the products.

2.2.1 VICAR Image Data File Names

For all data files stored in the MIPS Working Mission Storage (WMS), the filenames will be constructed with four parts as shown below in Figure D.

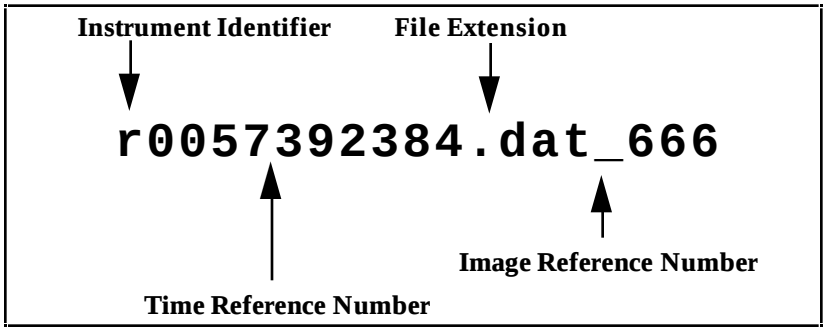

Figure D. — *Sample Rover Image File Name*

Instrument Identifier - The instrument identifier will always be the lowercase letter ‘r’, representing the rover.

Time Reference Number - The time reference number will be the 10-digit Spacecraft Clock Start Count, as described in Appendix A.

File Extension - The file extension is a three character mnemonic that will always be used for data files. Monochrome and packed-color rear camera image files will have a file extension of "img," and unpacked rear camera image files (color image files) will have an extension of "rgb."

Image Reference Number - Finally, the image reference number is the Command Sequence Number appended onto the file extension.

2.2.2 PDS Data File Names

The PDS data filenames will be constructed with four of the five VICAR image data filenames components as shown below in Figure E.

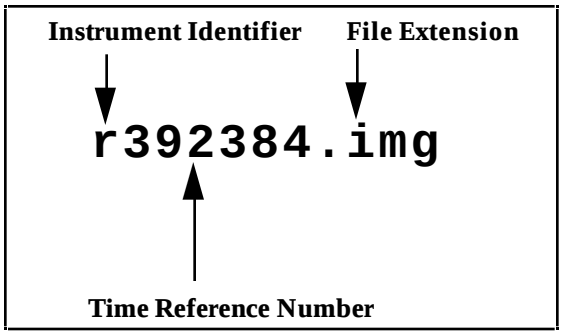

Figure E. — *Sample PDS Data File Name*

Instrument Identifier - The instrument identifier will always be the lowercase letter ‘r’.

Time Reference Number - The time reference number will be the least significant 6-digits of the Spacecraft Clock Start Count (the 4 significant digits will be used as part of the directory hierarchy storing the image files).

File Extension - Finally, the file extension will be the same three character mnemonic, Monochrome and packed-color rear camera image files will have a file extension of "img," and unpacked rear camera image files (color image files) will have an extension of "rgb."

2.2.3 PDS Label File Names

The PDS label filenames will be constructed with four of the five VICAR image data filenames components as shown below in Figure F.

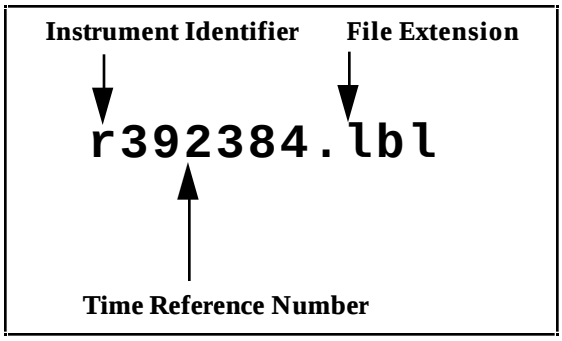

Figure F. — *Sample Label File Name*

Instrument Identifier - The instrument identifier will always be the lowercase letter ‘r’.

Time Reference Number - The time reference number will be the least significant 6-digits of the Spacecraft Clock Start Count (the 4 significant digits will be used as part of the directory hierarchy storing the image files).

File Extension - Finally, the file extension will always be the three character mnemonic ‘lbl’.

2.2.4 Valid File Extensions

Just to summarize, the valid file extensions are:

.img *for single-band images from any Rover camera*
.rgb *for band-sequential, color images from Rover rear camera*
.lbl *for PDS label files*

APPENDIX Rover PDS/VICAR EDR Label Items

The following pages list alphabetically the label items which are contained in the PDS and VICAR labels associated with each image file.

Table A-1 — *Common Rover Label Items*

Label Item	Description	Data Type (organization)	Valid Values
APPLICATION_PACKET_ID	Classifies the telemetry packet from which the image data was obtained. This packet ID is handed to the Telemetry download. This value is based on a set of values specified in the Downlink Telemetry Documents (JPL). This acronym is APID.	integer	(see Mars Pathfinder Rover Telemetry Dictionary [3])
AZIMUTHAL_FOV	The angular coverage of the imaged scene measured horizontally with respect to the image plane in spacecraft coordinates; units are radians.	floating point	2.2 radians
COMMAND_SEQUENCE_NUMBER	Number from corresponding uplink command (zero for autonomously generated messages)	integer	<any positive value>
EARTH_RECEIVE_START_TIME	Identifies the ealiest time a packet was received that conatained data for the image.	character array	YYYY-MM-DDThh:mm:ss
EARTH_RECEIVE_STOP_TIME	Identifies the latest time a packet was received that conatained data for the image.	character array	YYYY-MM-DDThh:mm:ss
ELEVATIONAL_FOV	The angular coverage of the imaged scene measured vertically with respect to the image plane in spacecraft coordinates; units are radians.	floating point	1.6 radians
EXPECTED_PACKETS	Total number of telemetry packets which constitute a complete image, an image without missing data.	integer	<any positive value>
EXPOSURE_DURATION	Integration time for CCD measured in milliseconds	integer	<any positive value>
FIRST_LINE	Indicates the line within a source image that corresponds to the first line in a sub-image.	integer	[1,492] for front camera; [1,768] for rear camera.
FIRST_LINE_SAMPLE	Indicates the sample within a source image that corresponds to the first sample in a sub-image.	integer	[1,768] for front camera; [1,492] for rear camera.
FOCAL_CENTER_VECTOR	Position of the entrance pupil point of the camera lens (focal center) measured relative to the external coordinate system. Corresponds to the C vector in the CAHV camera model.	floating point (array of 3 elements)	N.A.

† - *for PDS labels only*
* - *for Mosaic products only*

Table A-1 — *Common Rover Label Items*

Label Item	Description	Data Type (organization)	Valid Values
FRAME_ID	Provides an identification for a particular instrument measurement frame.	character (array)	LEFT, RIGHT, REAR
HORIZONTAL_IMAGE_PLANE_VECTOR	$\mathbf{H} = \mathbf{H}' + x_C\mathbf{A}$, where $\mathbf{H}'$ is a unit vector parallel to the x-axis in the camera's image plane, and x_C is the point of intersection of a perpendicular dropped from the exit pupil point of the camera lens. **H', A', V'** are mutually orthogonal. Corresponds to the H vector in the CAHV camera model.	floating point (array of 3 elements)	N.A.
IMAGE_ID	Unambiguously identifies an image. IMAGE_ID is a concatenation of APID code letter, and command sequence number. Each APID code maps to a APID code letter to be used in the IMAGE_ID. The following is a mapping of number to uppercase letter: 8, 'S'; 9, 'T'; 10, 'L'; 24, 'A'; 25, 'N'. 'S' represents science; 'T' represents technology; 'L' represents Lander engineering; 'A' represents autonomous; and 'N' represents operations or navigation. A sample image id is "L09329," where this image is a Lander engineering image. The command sequence number is 09329.	character (array) of length 6.	N.A.
IMAGE_TIME	Time at which the image was acquired, recorded in UTC format.	character (array)	YYYY-MM-DDThh:mm:ss.ffff
INSTRUMENT_COMPRESSION_BLK_SIZE	Dimension of a block for compression; line dimension of the block is the first element, followed by the sample dimension of the block.	integer (array)	(4,4)
INSTRUMENT_COMPRESSION_BLOCKS	Number of blocks used to spatially segment the image file prior to compression.	integer	<any positive value that is the image number of pixels divided by the block area>
INSTRUMENT_COMPRESSION_RATE	Average number of bits needed to represent a pixel with a compressed image.	floating point	<any positive value>

† - *for PDS labels only*
* - *for Mosaic products only*

Table A-1 — *Common Rover Label Items*

Label Item	Description	Data Type (organization)	Valid Values
INSTRUMENT_COMPRESSION_RATIO	Ratio in bytes of the original, uncompressed data file length to its compressed form. For example, a compression ratio of 5.00 means that on average, for every five bytes of input data, one byte of compressed data was generated.	floating point	<any positive value>
INSTRUMENT_COMPRESSION_TYPE	The type of compression or encryption used for data storage. Contents of this value should be the full, unabbreviated, non-acronym name of coding or compression type. Examples of encoding types include but are not limited to Integer Cosine Transform (ICT), Block Truncation Coding (BTC), Discrete Cosine Transform (DCT), Joint Photographic Experts Group (JPEG) Standard DCT.	character (array)	"Block Truncation Coding (BTC)"
INSTRUMENT_NAME	Full name of an instrument.	character (array)	"ROVER CAMERA LEFT" or "ROVER CAMERA RIGHT" or "ROVER CAMERA REAR"
INSTRUMENT_TEMPERATURE	The temperature of the sensor (CCD) array when the image was acquired, measured in degrees Celsius.	floating point	N.A.
LINEAR_ACCELEROMETER	X and Y readings for linear accelerometers on the Rover spacecraft. X indicates pitch, where positive values indicate Rover front is lower; Y indicates roll, where positive values indicating right side is lower. Values are in units of g where 1 g equals 9.8 m/sec**2. Thus, raw readings from telemetry are multiplied by 0.0009765 g,	floating point (array of two elements)	N.A.
LOCAL_TIME	Reference time based on the IAU standard for the Martian prime meridian. For detailed description, see the Report of the IAU/IAG/COSPAR Working Group on Cartographic Coordinates and Rotational Elements of the Planets and Satellites: 1991.	character (array)	hh:mm:ss.fff
MAXIMUM	The maximum Dn value in the image file, between the IMP CCD valid range (0 to 4095).	integer	[0, 4095]
MEAN	The mean pixel value for the pixels within the valid Dn range.	floating point	[0.0, 4095.0]

† - *for PDS labels only*
* - *for Mosaic products only*

Table A-1 — *Common Rover Label Items*

Label Item	Description	Data Type (organization)	Valid Values
MEDIAN	The median pixel value for the pixels within the valid Dn range. This value will be at most 8 Dn greater than or eqaul to the true median value.	integer	[0, 4095]
MINIMUM	The minimum Dn value in the image file, between the IMP CCD valid range (0 to 4095).	integer	[0, 4095]
MISSION_NAME	A major planetary mission or project.	character (array)	"MARS PATHFINDER"
POINTING_DIRECTION_VECTOR	A unit vector **A** in the direction in which the first (or second) camera is pointed; the direction of the symmetry axis of the camera lens as measured in the external coordinate system. Corresponds to the A vector in the CAHV camera model.	floating point (array of 3 elements)	N.A.
PRODUCER_ID	Short name or acronym for the producer or producing team / group of a dataset.	character (array)	"Rover Team / MIPS"
PRODUCT_CREATION_TIME	Defines the UTC time when a product was created.	time	YYYY-MM-DDThh:mm:ss.fff
PRODUCT_ID	A permanent, unique identifier assigned to a data product by its producer.	character (array)	"RVR_EDR-<image id>-<frame id>"
RECEIVED_PACKETS	Total number of telemetry packets which constitute the reconstructed image.	integer	<any positive value>
ROVER_HEADING	Angular measure clockwise from Lander north in BAMS (Binary Angle Measurement, where 2^16 BAMS equals one revolution).	integer	[0,65535]
ROVER_POSITION	X and Y offsets in millimeters north and east, respectively, of the Lander reference.	floating point (array of two elements)	N.A.
SOFTWARE_VERSION_ID	Identifies the version of the telemetry processing software used to generate the image data.	character (array)	N.A.

† - *for PDS labels only*
* - *for Mosaic products only*

Table A-1 — *Common Rover Label Items*

Label Item	Description	Data Type (organization)	Valid Values
SOURCE_PRODUCT_ID	Filenames of SPICE kernels used to produce image data and derived data.	character (array)	<standard SPICE kernel names for PCK, SPK, etc.>
SPACECRAFT_CLOCK_START_COUNT	CCSDS coarse time in seconds past January 1, 1958. This is the time at which the Rover formats the packet for delivery to the Lander.	integer	<any positive value>
SPACECRAFT_NAME	Full, unabbreviated name of a spacecraft.	character (array)	"MARS PATHFINDER ROVER"
STANDARD_DEVIATION	Stardard deviation of the valid pixel values around the mean Dn value.	floating point	[0.0, 4095.0]
TARGET_NAME	Identifies a target, be it a planetary body, region or feature.	character (array)	<Mars or some Martian feature>
TLM_CMD_DISCREPANCY_FLAG	Indicator of mismatch(es) found between Rover commands uplinked and Rover telemetry.	character (array)	TRUE, FALSE
VERTICAL_IMAGE_PLANE_VECTOR	$\mathbf{V} = \mathbf{V}' + y_C\mathbf{A}$, where $\mathbf{V}'$ is a unit vector parallel to the y-axis in the camera's image plane, and y_C is the point of intersection of a perpendicular dropped from the exit pupil point of the camera lens. $\mathbf{H}', \mathbf{A}', \mathbf{V}'$ are mutually orthogonal. Corresponds to the V vector in the CAHV camera model.	floating point (array of 3 elements)	N.A.

† - *for PDS labels only*
* - *for Mosaic products only*

Table A--2— *PDS Rover Label Items*

Label Item	Description	Data Type (organization)	Valid Values
APID_DESCRIPTION †	Group name associated with APID. An example is "Lander image of the Rover" for APID #26.	character (array)	<any descriptive text>
BAND_SEQUENCE†	The order in which spectral bands are stored in an image. This keyword-value pair only appears when INSTRUMENT_NAME is REAR.	character (array 20)	(RED, GREEN, BLUE)
BAND_STORAGE_TYPE†	The storage sequence of lines, samples, bands in an image. This keyword-value pair only appears when INSTRUMENT_NAME is REAR.	character (array 20)	"BAND SEQUENTIAL"
BANDS †	Indicates the number of spectral bands in the image.	integer	1
CHECKSUM†	An unsigned 32-bit sum of all data in the image data object.	integer	<any positive value>
COMMAND_DESCRIPTION†	Text which describes the uplinked command as found in COMMAND_NAME element.	varchar (200)	<text taken directly from the Mars Pathfinder Command Dictionary, appendix A, D-12500>
DATA_SET_ID†	A unique alphanumeric identifier for a data set or a data product. This identifier consists of the identifiers for spacecraft, target, instrument, processing level, product acronym, and version number.	character (array)	"MPFR-M-RVRCAM-2-EDR-Vx.x"
DATA_SET_NAME†	Full name given to a data set or product. This is an unabbreviated version of the DATA_SET_ID.	character (array)	"MARS PATHFINDER ROVER MARS ROVER CAMERA EDR Vx.x"
DETECTOR_PIXEL_HEIGHT †	Height of pixel measured in microns.	floating point	<TBD>
DETECTOR_PIXEL_WIDTH †	Width of pixel measured in microns.	floating point	<TBD>
FILE_RECORDS†	Number of physical file records.	integer	<any positive value>

† - *for PDS labels only*
* - *for Mosaic products only*

Table A--2— *PDS Rover Label Items*

Label Item	Description	Data Type (organization)	Valid Values
INSTRUMENT_COMPRESSION_DESC†	Textual description of encoding type, which should include a reference to a journal paper, published text or some other publicly available, published material which definitively describes the on-board compression type.	character (array)	N.A.
INSTERCHANGE_FORMAT†		character (array)	
LINES†	Total number of pixels along the vertical axis of an image.	integer	<any positive value>
LINE_SAMPLES†	Total number of pixels along the horizontal axis of an image.	integer	<any positive value>
PDS_VERSION_ID†	The version number of the PDS standards documents that is valid when a data product is created.	character (array)	3 or greater
PROCESSING_HISTORY_TEXT†	Textual summation that provides an entry for each processing step and program used in generating a particular data file in the context of the Ground Data System.	character (array)	N.A.
PRODUCER_FULL_NAME†	Full, unabbreviated name of the individual mainly responsible for the production of the data set.	character (array)	"Mars Pathfinder Rover Team in concert with the Multimission Image Processing Subsystem"
PRODUCER_INSTITUTION_NAME†	Identifies the institution associated with the production of the data set.	character (array)	"Jet Propulsion Laboratory (JPL)"
RECORD_BYTES†	Number of bytes in a physical file record, including record terminators and separators.	integer	80
RECORD_TYPE†	Record format of a file.	character (array)	FIXED_LENGTH
SAMPLE_BITS†	Indicates the stored number of bits, or units of binary information, contained in a line_sample value.	integer	8
SAMPLE_BIT_MASK†	Identifies the active bits in a sample.	character	2#11111111#

† - *for PDS labels only*
* - *for Mosaic products only*

Table A--2— *PDS Rover Label Items*

Label Item	Description	Data Type (organization)	Valid Values
SAMPLE_TYPE†	Data storage representation of sample value.	character (array)	MSB_UNSIGNED_ INTEGER
SPACECRAFT_ID	Mneumonic for spacecraft name.	character (array)	MPFR

† - *for PDS labels only*
* - *for Mosaic products only*

Table A-3 -— Desireable *Rover Label Items*

Label Item	Description	Data Type (organization)	Valid Values
INERTIAL_TO_AREOCENTRIC_TRANSFORM	The coordinate transformation from J2000 inertial frame to the body-fixed, planetocentric frame of Mars. This transformation is defined in terms of right ascension, declination, angular offset of the prime meridian of Mars as stored in the PCK kernel file provided by NAIF.	double (array)	N.A.
MFX_TO_MBF_TRANSFORM	The coordinate transformation from Mars Surface Fixed frame (MFX frame) to the body-fixed frame of Mars (MBF frame).	double (array)	N.A.
SOLAR_AZIMUTH (May be eliminated due to limited resources ... available in SPICE kernels)	The angular distance in a horizontal direction of the sun relative to the camera pointing for a particular image, measured in degrees clockwise in a spherical coordinate system.	floating point	[0, 360.0]
SOLAR_ELEVATION (May be eliminated due to limited resources ... available in SPICE kernels)	The angular distance in a vertical direction of the sun relative to the horizon as seen by the camera, measured in degrees up in a spherical coordinate system.	floating point	[-90.0, 90.0]
SPACECRAFT_ALTITUDE (May be eliminated due to limited resources ... available in SPICE kernels)	Distance (in meters) above gravitational center of Mars.	floating point	N.A.
SPACECRAFT_LATITUDE (May be eliminated due to limited resources ... available in SPICE kernels)	Latitude on Mars at which the spacecraft rests using a Planetocentric coordinate system.	floating point	[-90.0, 90.0]
SPACECRAFT_LONGITUDE (May be eliminated due to limited resources ... available in SPICE kernels)	Degrees of East Longitude on Mars at which the spacecraft rests using a planetocentric coordinate system.	floating point	[0.0, 360.0]
SURFACE_NORMAL_AZIMUTH (May be eliminated due to limited resources ... available in SPICE kernels)	Azimuthal measure of surface normal at the ground intersection point from the geometric center of the Lander base to the gravitional center of Mars.	floating point	N.A.
SURFACE_NORMAL_ELEVATION (May be eliminated due to limited resources ... available in SPICE kernels)	Elevational measure of surface normal at the ground intersection point from the geometric center of the Lander base to the gravitional center of Mars.	floating point	N.A.

† - *for PDS labels only*

APPENDIX B
Rover VICAR Property and Task Labels

B.1 Rover VICAR Property and Task Labels

The following pages contain alphabetical listings of the VICAR label items which are placed in the header of each image file. The listings are arranged by VICAR property or task name.

VICAR LABEL ITEM

CAMERA_MODEL Property

AZIMUTH_FOV
ELEVATION_FOV
FOCAL_CENTER_VECTOR
HORIZONTAL_IMAGE_PLANE_VECTOR
POINTING_DIRECTION_VECTOR
VERTICAL_IMAGE_PLANE_VECTOR

DECOMPRESSED Property

INSTRUMENT_COMPRESSION_BLK_SIZE
INSTRUMENT_COMPRESSION_BLOCKS
INSTRUMENT_COMPRESSION_RATE
INSTRUMENT_COMPRESSION_RATIO
INSTRUMENT_COMPRESSION_TYPE

MPFTELEMPROC Property

EARTH_RECEIVE_START_TIME
EARTH_RECEIVE_STOP_TIME
EXPECTED_PACKETS
INSTRUMENT_NAME
MISSION_NAME
PRODUCER_ID
PRODUCT_CREATION_TIME
PRODUCT_ID
RECEIVED_PACKETS
SOFTWARE_VERSION_ID
SOURCE_PRODUCT_ID
SPACECRAFT_NAME
TLM_CMD_DISCREPANCY_FLAG

OBSERVATION Property

APPLICATION_PACKET_ID
EXPOSURE_DURATION
FIRST_LINE
FIRST_LINE_SAMPLE
FRAME_ID
IMAGE_ID
IMAGE_TIME
INSTRUMENT_TEMPERATURE
LINEAR_ACCELEROMETER
LOCAL_TIME
MAXIMUM
MEAN
MEDIAN

VICAR LABEL ITEM
MINIMUM
ROVER_HEADING
ROVER_POSITION
SPACECRAFT_CLOCK_START_COUNT
STANDARD_DEVIATION
TARGET_NAME

RVR_Command Property

COMMAND_SEQUENCE_NUMBER

VICAR LABEL ITEM

PDS Label items

APID_DESCRIPTION
BAND_SEQUENCE
BAND_STORAGE
BANDS
CHECKSUM
COMMAND_DESCRIPTION
DATA_SET_ID
DATA_SET_NAME
DETECTOR_PIXEL_HEIGHT
DETECTOR_PIXEL_WIDTH
FILE_RECORDS
INSTRUMENT_COMPRESSION_DESC
INTERCHANGE_FORMAT
LINES
LINE_SAMPLES
PDS_VERSION_ID
PROCESSING_HISTORY_TEXT
PRODUCER_FULL_NAME
PRODUCER_INSTITUTION_NAME
RECORD_BYTES
RECORD_TYPE
SAMPLE_BITS
SAMPLE_BIT_MASK
SAMPLE_TYPE

Desirable items

INERTIAL_TO_AREOCENTRIC_TRANSFORM
SOLAR_AZIMUTH
SOLAR_ELEVATION
SPACECRAFT_ALTITUDE
SPACECRAFT_LATITUDE
SPACECRAFT_LONGITUDE
SURFACE_NORMAL_AZIMUTH
SURFACE_NORMAL_ELEVATION